

OXIDATION–REDUCTION REACTIONS

SECTION 20.1 THE MEANING OF OXIDATION AND REDUCTION (pages 631–638)

This section explains oxidation and reduction in terms of the loss or gain of electrons, and describes the characteristics of a redox reaction. It also explains how to identify oxidizing and reducing agents.

► What are Oxidation and Reduction? (pages 631–635)

1. What was the original meaning of the term *oxidation*? _____

2. Circle the letter of each sentence that is true about oxidation.
 - a. Gasoline, wood, coal, and natural gas (methane) can all burn in air, producing oxides of carbon.
 - b. All oxidation processes involve burning.
 - c. Bleaching is an example of oxidation.
 - d. Rusting is an example of oxidation.
3. Look at Figure 20.2 and Figure 20.3 on page 632. Describe what is happening in each chemical reaction.
 - a. $\text{C(s)} + \text{O}_2\text{(g)} \longrightarrow \text{CO}_2\text{(g)}$ _____

 - b. $4\text{Fe(s)} + 3\text{O}_2\text{(g)} \longrightarrow 2\text{Fe}_2\text{O}_3\text{(s)}$ _____

4. What is the name of the process that is the opposite of oxidation?

5. Circle the letter of each sentence that is true about oxidation and reduction.
 - a. Oxidation never occurs without reduction and reduction never occurs without oxidation.
 - b. You need to add heat in order to reduce iron ore to produce metallic iron.
 - c. When iron oxide is reduced to metallic iron, it gains oxygen.
 - d. Oxidation–reduction reactions are also known as redox reactions.

CHAPTER 20, Oxidation–Reduction Reactions (*continued*)

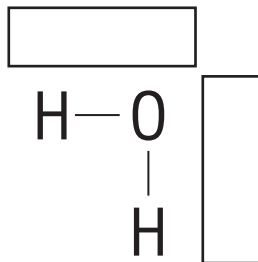
6. What substance is heated along with iron ore in order to reduce the metal oxide to metallic iron? _____
7. Look at the chemical equation for the reduction of iron ore on page 632. When iron ore is reduced to metallic iron, what oxidation reaction occurs at the same time? _____
8. Is the following sentence true or false? The concepts of oxidation and reduction have been extended to include many reactions that do not even involve oxygen. _____
9. What is understood about electrons in redox reactions?

10. In the table below, fill in either “Gain” or “Loss” to correctly describe what happens to electrons or oxygen during oxidation or reduction.

	Oxidation	Reduction
Electrons		
Oxygen		

11. Look at Figure 20.4 on page 633. Circle the letter of each sentence that is true about the reaction of magnesium and sulfur.
- a. When magnesium and sulfur are heated together, they undergo a redox reaction to form magnesium sulfide.
 - b. Electrons are transferred from the metal atoms to the nonmetal atoms in this reaction.
 - c. When magnesium atoms lose electrons and sulfur atoms gain electrons, the atoms become less stable.
 - d. Magnesium is the oxidizing agent and sulfur is the reducing agent in this reaction.
12. Is the following sentence true or false? In any redox reaction, complete electron transfer must occur. _____
13. Is the following sentence true or false? A redox reaction may produce covalent compounds. _____

14. Draw arrows showing the shift of bonding electrons during formation of a water molecule. Then complete the table listing the characteristics of this reaction.



Formation of Water by Reaction of Hydrogen and Oxygen	
Chemical equation	
Shift of bonding electrons	
Reduced element	
Oxidized element	
Reducing agent	
Oxidizing agent	
Is heat released or absorbed?	

15. For each process described below, label it *O* if it is an oxidation or *R* if it is a reduction.

- _____ a. Addition of oxygen to carbon or carbon compounds
- _____ b. Removal of a metal from its ore
- _____ c. Complete gain of electrons in an ionic reaction
- _____ d. Shift of electrons away from an atom in a covalent bond
- _____ e. Gain of hydrogen by a covalent compound

► Corrosion (pages 636–638)

16. Circle the letter of each sentence that is true about corrosion.
- a. Preventing and repairing damage from corrosion of metals requires billions of dollars every year.
 - b. Iron corrodes by being oxidized to ions of iron by oxygen.
 - c. Water in the environment slows down the rate of corrosion.
 - d. The presence of salts and acids increases the rate of corrosion by producing conducting solutions that make the transfer of electrons easier.

CHAPTER 20, Oxidation–Reduction Reactions (*continued*)

17. Why are gold and platinum called noble metals? _____

18. Look at Figure 20.6 on page 636. Why is corrosion desirable in the situation shown? _____

19. Look at Figure 20.7 on page 636. Complete the sketch below to show how oxides form on the surface of each metal. Explain how differences between the oxides affect further corrosion of the metals.

**SECTION 20.2 OXIDATION NUMBERS** (pages 639–643)

This section explains how to determine the oxidation number of an atom of any element in a pure substance and defines oxidation and reduction in terms of a change in oxidation number.

► Assigning Oxidation Numbers (pages 639–641)

1. Is the following sentence true or false? As a general rule, a bonded atom's oxidation number is the charge that it would have if the electrons in the bond were assigned to the more electronegative element. _____
2. For each binary ionic compound listed in the table, write the symbols for both ions, their ionic charges, and their oxidation numbers.

Compound	Ions	Ionic Charges	Oxidation Numbers
NaCl			
CaF ₂			

3. Is the following sentence true or false? Even though water is a molecular compound, you can still obtain oxidation numbers for the bonded elements by imagining that the electrons contributed by the hydrogen atoms are completely transferred to oxygen. _____
4. Write the oxidation number, or the sum of the oxidation numbers, for the given atoms, ions, or compounds.
- _____ a. Cu(II) ion
- _____ b. Hydrogen in water
- _____ c. Hydrogen in sodium hydride (NaH)
- _____ d. Potassium sulfate (K_2SO_4)

► Oxidation-Number Changes in Chemical Reactions (page 642)

5. Label each change *O* if it describes oxidation or *R* if it describes reduction.
- _____ a. Decrease in the oxidation number of an element
- _____ b. Increase in the oxidation number of an element

SECTION 20.3 BALANCING REDOX EQUATIONS (pages 645–654)

This section explains how to use the oxidation-number-change and half-reaction methods to balance redox equations.

► Identifying Redox Reactions (pages 645–647)

1. Name two kinds of reactions that are not redox reactions.
- _____

2. Look at Figure 20.15b on page 645. Write the oxidation numbers of all the elements in the reactants and products. Then answer the questions about the reaction.

	Reactants			Products	
	Zinc	Hydrochloric acid		Zinc chloride	Hydrogen
Oxidation numbers	_____	_____		_____	_____
Chemical equation	Zn(s)	+ HCl(aq)	→	ZnCl ₂ (aq)	+ H ₂ (g)

a. Is this a redox reaction? _____

b. Which element is oxidized? How do you know?

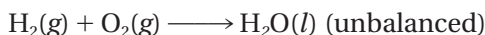
c. Which element is reduced? How do you know?

CHAPTER 20, Oxidation–Reduction Reactions (*continued*)

3. When a solution changes color during a reaction, what can you conclude about the reaction that has taken place?
- _____

► **Two Ways to Balance Redox Equations** (pages 647–652)

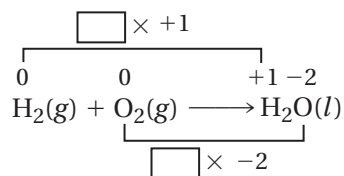
4. Answer these questions to help you balance the following equation using the oxidation-number-change method.



- a. What are the oxidation numbers for each atom in the equation?

- b. Which element is oxidized in this reaction? Which is reduced?
- _____

- c. Use your answers to question *a* above to balance the equation. Write the coefficients needed to make the total change in oxidation number equal to 0.



- d. What is the final balanced equation? _____

5. The equations for which reactions are balanced separately when using the half-reaction method? _____
- _____

6. For what kind of reaction is the half-reaction method particularly useful?
- _____

► Choosing a Balancing Method (page 653)

7. Why would you choose to use oxidation-number changes to balance an equation?

8. What method would you choose to balance an equation for a reaction that takes place in an acidic or alkaline solution?



Reading Skill Practice

A flowchart can help you to remember the order in which events occur. On a separate sheet of paper, create a flowchart that describes the steps for the oxidation-number-change method. This process is explained on page 648 of your textbook.

CHAPTER 20, Oxidation–Reduction Reactions (*continued*)

GUIDED PRACTICE PROBLEM

GUIDED PRACTICE PROBLEM 9 (page 641)

9. Determine the oxidation number of each element in these substances.

a. S_2O_3

Step 1. What is the oxidation number for oxygen? Use rule 3. _____

Step 2. What is the oxidation number for all of the oxygen atoms?

Step 3. What is the oxidation number for all of the sulfur atoms? _____

Step 4. What is the oxidation number for each sulfur atom? _____

Step 5. How do you know your answers are correct?

b. Na_2O_2

Step 1. What is the oxidation number of oxygen? Use rule 3.

(Hint: This compound is a peroxide.) _____

Step 2. What is the oxidation number of sodium? _____

Step 3. How do you know your answer is correct?

The oxidation number for both oxygen atoms is _____. The sum of the oxidation numbers for all the atoms must be _____. Therefore, the oxidation number for both sodium atoms must equal _____.

c. P_2O_5

Step 1. What is the oxidation number for oxygen? Use rule 3. _____

Step 2. What is the oxidation number for all of the oxygen atoms?

$$-2 \times 5 = \underline{\hspace{2cm}}$$

Step 3. What is the oxidation number for all of the phosphorous atoms? _____

Step 4. What is the oxidation number for each phosphorous atom?

$$+10 \div 2 = \underline{\hspace{2cm}}$$

Step 5. How do you know your answers are correct?

d. NH_4^+

Step 1. What is the oxidation number for hydrogen? Use rule 2. _____

Step 2. What is the oxidation number for all of the oxygen atoms?

$$+1 \times 4 = \underline{\hspace{2cm}}$$

Step 3. What is the oxidation number for the nitrogen atom? _____

Step 4. How do you know your answers are correct?

e. Ca(OH)_2

Step 1. What is the oxidation number for oxygen? Use rule 3. _____

Step 2. What is the oxidation number for all of the oxygen atoms?

$$-2 \times 2 = \underline{\hspace{2cm}}$$

Step 3. What is the oxidation number for hydrogen? Use rule 2. _____

What is the oxidation number for the hydroxide (OH)?

$$-2 + +1 = \underline{\hspace{2cm}}$$

Step 5. What is the oxidation number for all of the hydroxide?

$$-1 \times 2 = \underline{\hspace{2cm}}$$

Step 6. What is the oxidation number for the calcium atom? _____

Step 7. How do you know your answers are correct?

f. $\text{Al}_2(\text{SO}_4)_3$

Step 1. What is the charge of the polyatomic sulfate ion?

Step 2. What is the oxidation number of oxygen? Use rule 3.

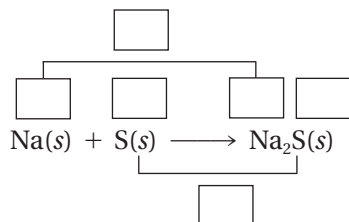
Step 3. What is the oxidation number of all of the oxygen atoms?

Step 4. What is the oxidation number of the sulfur atom?

Step 5. What is the oxidation number of the aluminum ion?

CHAPTER 20, Oxidation–Reduction Reactions (*continued*)**EXTRA PRACTICE** (similar to Practice Problem 19, page 649)

19. Balance this redox equation using the oxidation-number-change method.



To make the oxidation numbers balance, you must multiply the oxidation number of sodium by _____. Add a coefficient of _____ in front of elemental sodium, but not in front of sodium sulfate because the sodium in sodium sulfate has a subscript of _____. The balanced equation is _____.